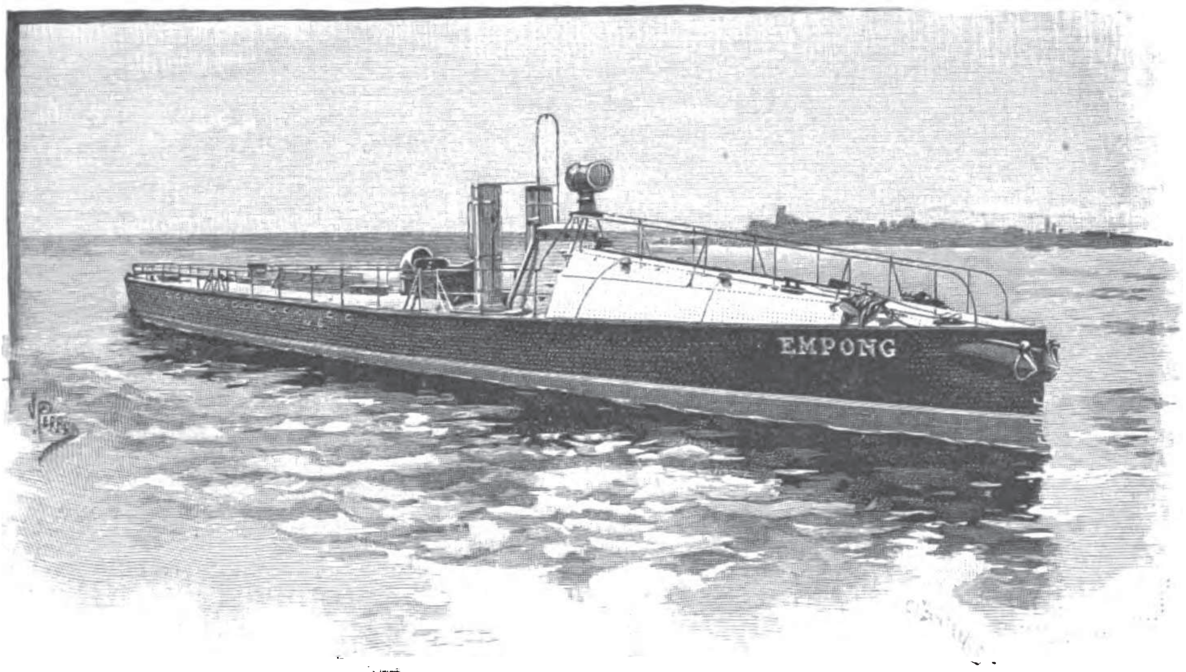




Yarrow Torpedo-boat Empong, showing Search-light.

# ELECTRICITY IN WAR.

## I.—IN NAVAL WARFARE.*

*By Lieutenant W. S. Hughes, U. S. Navy.*

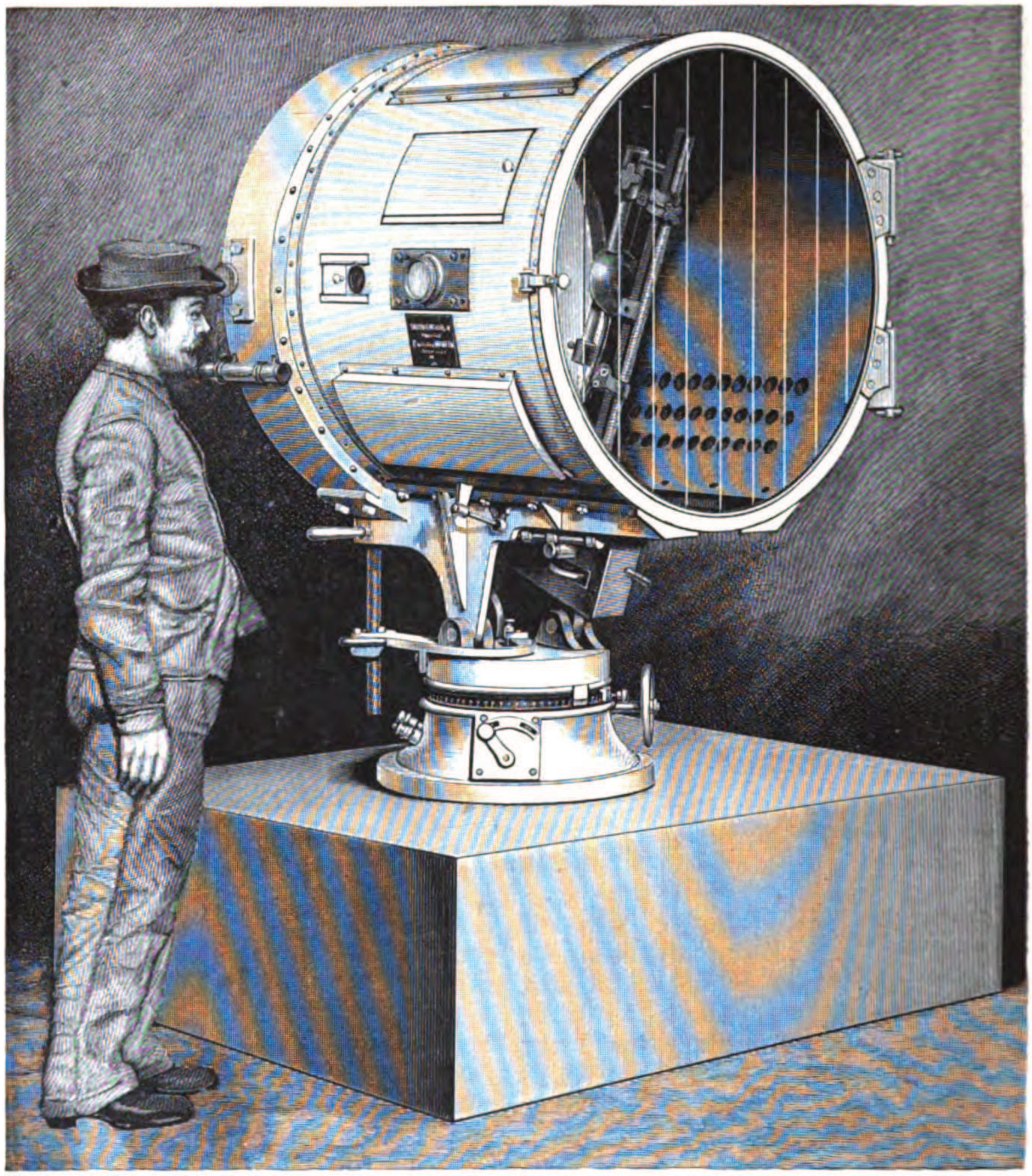
THE extension of the applications of electricity has been nowhere more rapid or remarkable than on board ships-of-war. Only a little more than six years have elapsed since the Navy Department fitted out the frigate Trenton with an electric incandescent plant, and, so far as is known, she was the first naval vessel to be lighted by electricity.

The experiment with the Trenton was watched with interest both at home and abroad. Serious apprehensions had been entertained that firing the ship's guns would break the glass bulbs, or destroy the carbon filaments of the lamps, and that other causes would operate against the successful employment of electricity on board a man-of-war; but the thorough test on the Trenton, lasting through a three-years' cruise, proved beyond question the fallacy of such fears.

Foreign countries were not slow to follow the footsteps of the United States, and the latter government gradually extended the system of electric lighting to other vessels of the navy.

It had been early discovered that the installation of an electric plant on board naval ships required a decided modification of the electrical appliances employed for similar purposes on shore. The limited space that could be spared on the crowded decks of a man-of-war demanded that engines and dynamos of a special and compact type should be used; and these requirements were further complicated by the necessity, which soon developed, of providing naval vessels with two systems of illumination. Gradually, however, man's ingenuity overcame every obstacle—and how completely, the reader will not fail to appreciate by a glance at the wonderfully compact electrical machinery included among the illustrations of this paper—until, at the present day, no modern-built vessel-of-war goes to sea without complete electrical plants, both "arc" and "incandescent," the latter principally for the purpose of interior light-

* In the preparation of this article the writer has been greatly indebted to valuable reports made to the U. S. Office of Naval Intelligence by Lieutenant J. B. Murdock, U. S. N., and by Mr. S. Dana Greene, late Ensign, U. S. N.



Ship-of-War's Search-light, 25,000 Candle-power.
(From a photograph furnished by Messrs. Sautter, Lemonnier & Company, Paris.)

ing, and the former for operating the so-called "search-light."

The name of the "search-light" suggests, to some extent, the chief purpose for which it is used. It is mainly employed in searching for an enemy. It consists of a powerful "arc" light, usually of about twenty-five thousand candle-power, contained in a metal cylinder about thirty inches long by twenty-four to thirty inches diameter. A good idea of its construction and general appearance may be obtained from the illustration above and the one on the opposite page.

One end of the cylinder is closed by a silvered, concave reflecting-lens; and the carbon points of the lamp, as represented in the sectional view, are placed in such a position within the cylinder as to bring them in the focus of the lens. The opposite, or front, end of the cylinder is fitted with a glass door through which the beam of light passes. Other mechanical features are shown in the illustrations.

The whole apparatus is mounted on a pivot, so that it may be revolved around its centre—and the beam of light be thus thrown in any desired direction—while it admits, also, of elevation or depression from a horizontal position.

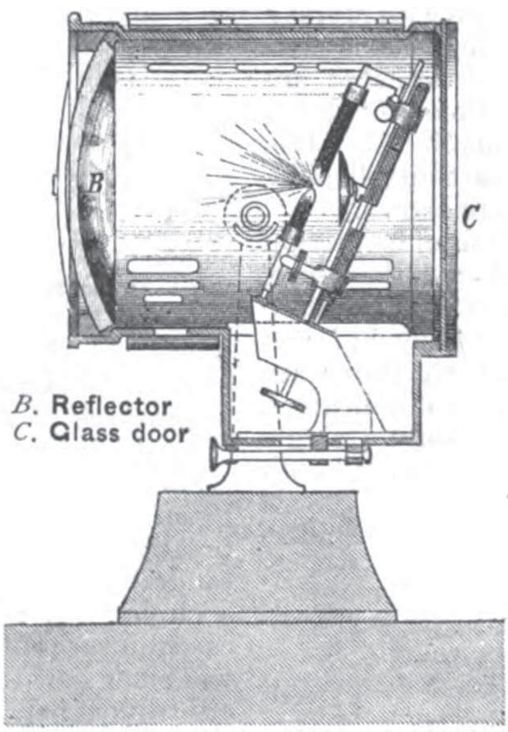
As ordinarily used on ships-of-war, the beam of light emerging from the cylinder is so concentrated that at a distance of a thousand yards from the ship it illuminates a path only about fifteen yards in width. Every search-light, however, is provided with arrangements for increasing the divergence of the rays of light, in order, when necessary, to illuminate a broader arc. Only one man is required to work the apparatus, and to facilitate its use it is always, on board ships, mounted in some position considerably elevated above the deck.

In time of war, ships at night would constantly sweep the surrounding waters with their search-lights, illuminating, in succession, every part of the circle around them, in order to detect the presence of an enemy; and the practical value of the light, in such cases, will be readily comprehended when it is understood that, with one of only twenty-thousand candle-power, no difficulty is experienced in lighting up any object, such as an enemy's ship, at a distance of two and a half miles; thus rendering firing the guns at night as easy and accurate as by day.

The view at the beginning of this article of the Empong, one of those phenomenally swift little vessels called "torpedo-boats," shows its search-light mounted on top of the pilot-tower, just in front of the two smoke-pipes.

In the practical use of the search-light, by the method just explained, it has been found that, in order to afford sufficient time for a careful examination of the water's surface at points far removed from the ship, the beam of light must be revolved very slowly; and, in consequence, during a great proportion of the time, any particular section of the water is in darkness. When it is remembered that it requires less than five minutes for modern torpedo-boats to pass over a distance of two miles, it may be easily conceived how, in the interval between two successive illuminations of the same spot, a little craft like the Empong might dart in and discharge its torpedoes.

With the object of averting such a danger, another method of illuminating the surrounding space has been adopted on one or two ships of the French Navy, and on the Danish cruiser Ivert, where, instead of a single revolving light, a number of stationary search-lights are grouped together, each illuminating its proper section, thus keeping the ship continuously surrounded by an unbroken circle of light.



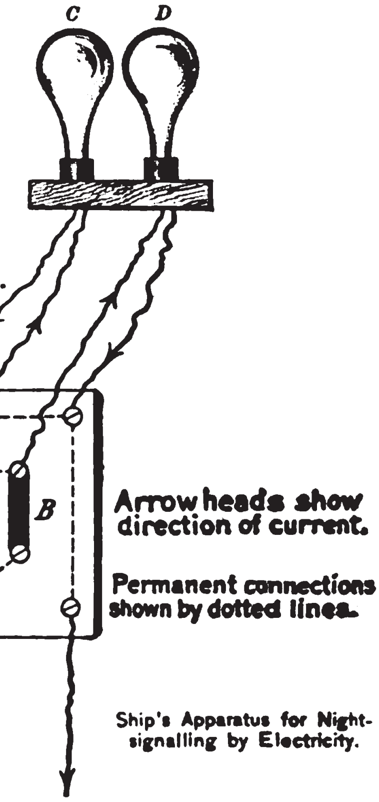
Sectional View of Ship's Search-light.
(From a sketch by Ensign H. H. Eames, U. S. N.)

But the search-light is not only used to discover an enemy, and to keep the latter visible in firing at night; it has been, also, successfully employed in signalling messages where the distances over which they are to be sent are very great. One of the methods of using it for this purpose is somewhat novel: the beam of light is simply flashed repeatedly against the clouds, lighting them up in each instance for a certain number of seconds, according to a pre-arranged code of signals, the letters of which are indicated by combinations of flashes of different durations of time. Messages are said to have been sent in this manner between ships separated by a distance of sixty miles. For shorter distances the ordinary incandescent lamps have been frequently used. Probably one of the most successful systems with these lamps is that now in use in the navies of Italy and Germany. Its essential feature consists in the successive display of different combinations of red and of white incandescent lamps of about fifty candle-power each. It is, of course, necessary that the lamps be exhibited in some elevated position, such, for example, as suspended from one of the ship's yards, where they will be plainly visible from a considerable distance, and that the electric current connected with them be under the control of an operator at a key-board, in order that any lamp may be ignited or extinguished at pleasure. With such an apparatus it will be readily understood how the letters of a signal-code could be indicated, and a message rapidly transmitted.

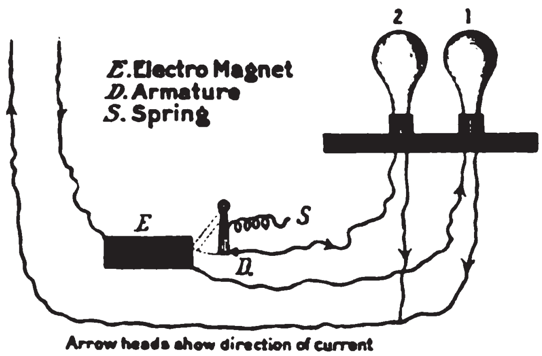
In the United States Navy a more simple plan, requiring only two incandescent lamps, has been very successfully used in connection with Morse's telegraphic code, in which, as is well known, the letters of the alphabet are represented by combinations of "dots" and "dashes." In signalling by this code the two lamps were controlled by keys, as in the figure here shown.

It will be observed, from an inspection of the electrical connections in the figure, that when the key A is pressed, the lamp C is alone ignited, or "flashed;" and that when B is pressed, both lamps are flashed simultaneously. To indicate a "dot" of the Morse code, only a single lamp is used; to denote a "dash," both are ignited together.

Every steamer displays, when under-way at night, as doubtless most of our readers have observed, three lights of different colors*—green, red, and white. These "running lights," as they are technically called, are exhibited on the outside of the ship, in such positions as to indicate to other vessels the approximate direction in which she is moving. To avoid collisions, and loss of human life, it is of vital importance that these lights be never for a moment extinguished. With the aid of electricity the possibility of such an accident as the unexpected extinguishing of a "running light"† at a critical moment will be reduced to a minimum, if not altogether eliminated, by an ingenious appliance in which the breaking or burning out of one incandescent lamp *automatically* completes a circuit and ignites another. Only a casual inspection of the figure to the left will show how this is effected: A small electro-magnet, E, is placed in the circuit of the lamp 1; and, while the latter is burning, the attraction of the magnet keeps the armature D in the position shown by the dotted lines, with the circuit of lamp 2 broken. But, should the circuit of 1 be broken by the burning out or breaking of the lamp, or from




Ship's Apparatus for Night-signalling by Electricity.




Arrangement of Electrical "Running Lights" for Ships.

* A green light on the starboard (or right) side; a red light on the port side, and a white light at the mast-head.

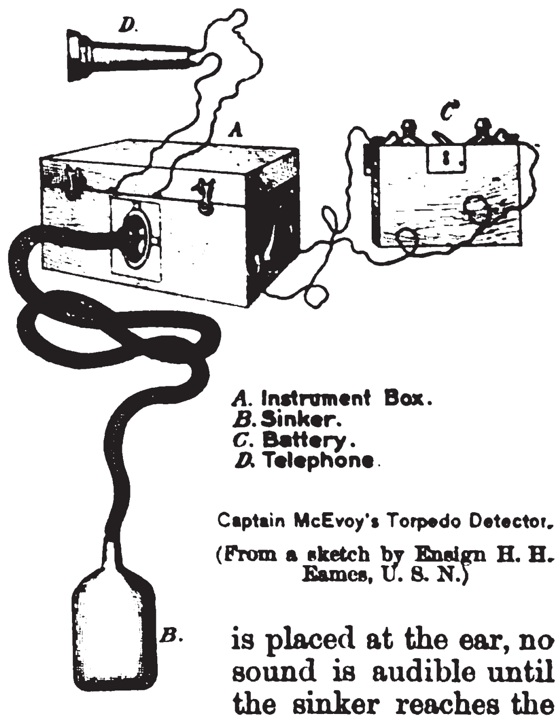
† Electric "running lights" have not been yet adopted by ships-of-war; but it seems probable that they will be used in the near future.—W. S. H.

any cause, the magnet will, of course, cease to attract the armature, and the latter is at once drawn back by a spring, S, to the position shown in the figure, thus completing the circuit and igniting lamp 2. The figure represents this as having already occurred.

Another application of the incandescent lamp has developed from a series of experiments made at the Naval Torpedo Station, Newport, R. I., with the object of ascertaining to what extent electricity could be utilized at night for lighting up water below the surface. In these experiments incandescent lamps of about one hundred and fifty candle-power were immersed to a depth of fifteen to twenty feet, with the result that sunken objects could be readily seen within the distance of a hundred feet from the light. The discovery thus made is of considerable importance from a naval point of view. Modern naval fleets must be not only prepared to rapidly remove the stationary torpedoes, or "fixed mines," with which every important port in time of war will be protected, but the ships themselves must be provided with a complete system of such weapons, ready to block up harbors in which an enemy's vessels may be discovered, or in which they themselves may have taken refuge. Much of this service, in the event of war, would be necessarily performed at night, and a part of it under water; hence, it may be certainly expected that modern navies will avail themselves of the valuable agent that the Newport experiments have placed in their hands. A portion of the force employed for such duty would be a body of trained divers; and, not only will these men carry with them under the water an electric light, but the telephone has been recently added to their outfit, so that they may communicate constantly and easily with assistants above the surface.

In this connection may be mentioned a remarkable electrical apparatus known as a "Torpedo Detector." As its name implies, it is designed for use in searching for hidden torpedoes, or mines, in harbors and channels. This appliance depends for its action upon the principle of the induction-balance. A representation of it is shown above. The box A, in the figure, contains a set of induction-coils, and a vibratory magneto-electric machine, with which a telephone is connected. The metal sinker B contains, also, a set of induction-coils, and is connected with A by a short electric cable. The small battery C has connections, as shown in the figure, the circuit of which can be opened or closed by a key.

In practical use, searching for torpedoes, the box and battery are carried in a boat, and the metal sinker, to which the small cable is attached, is dragged overboard along the bottom of a channel or harbor where the presence of torpedoes is suspected. When the telephone is placed at the ear, no sound is audible until the sinker reaches the vicinity of some metal body, such as a torpedo; then a buzzing noise is heard, which becomes gradually louder as the torpedo is approached, and loudest when it is touched.




*A.* Instrument Box.
*B.* Sinker.
*C.* Battery.
*D.* Telephone.

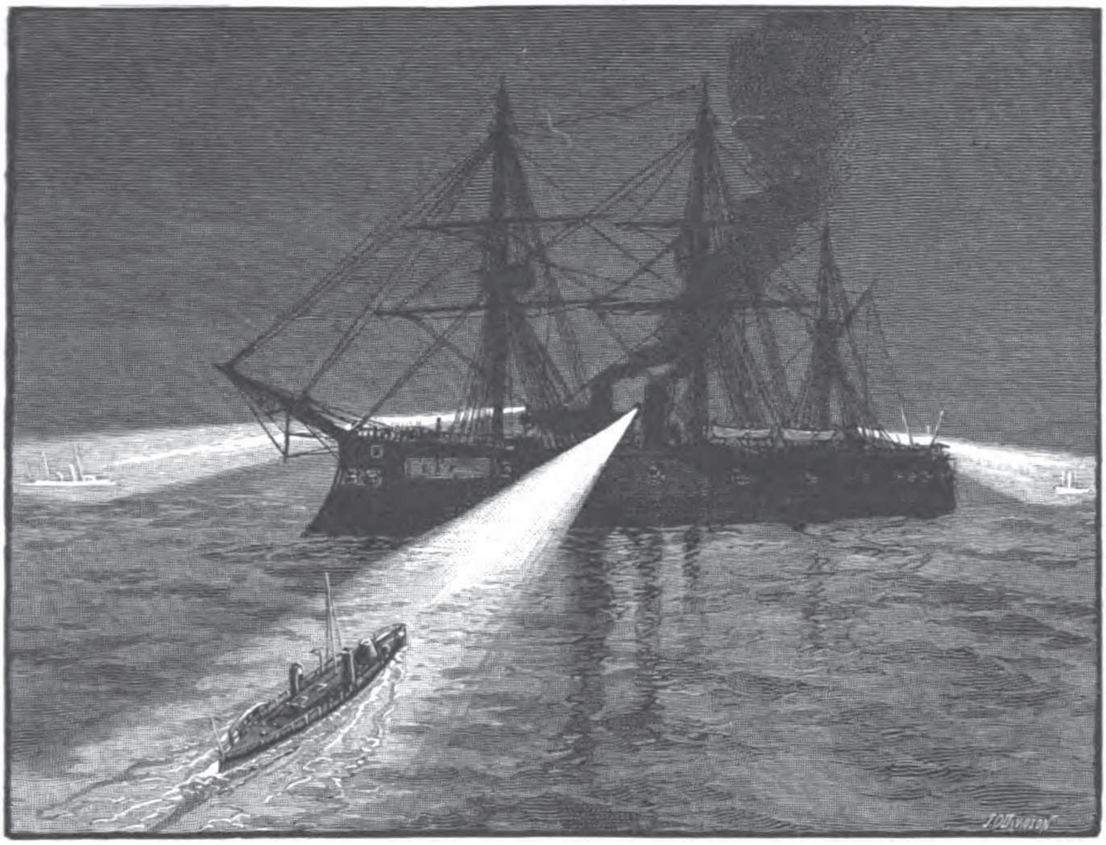
Captain McEvoy's Torpedo Detector.
(From a sketch by Ensign H. H. Eames, U. S. N.)

Electricity is employed on some of the vessels of the British Navy, and will probably be made use of on the new ships of the United States service, to render visible the sights of the guns when firing at night. As applied on the English iron-clad Colossus, one of the wires from a small Leclanché battery leads to the rear, or "breech," sight of the gun, and is there joined to a fine platinum wire running across the bottom of the "sight-notch." The platinum wire interposes just sufficient resistance to cause it to glow with heat while the current from the battery is passing through it. From the rear-sight the battery wire continues on to the front-sight of the gun, where it meets the second wire from the battery. Here the ends of the two wires are brought very near each other, at the apex of the sight, so that the electric sparks passing between them serve to mark its position. The practical utility of such an arrangement may be shown by a familiar illustration: Everyone has observed, when looking from the window of a lighted room on a dark night, how difficult it is to distinguish any outside object beyond the distance of a few feet. The same effect is naturally experienced on board ship, and for this reason, among others, men-of-war, on going into battle at night, have every unnecessary light extinguished — thus rendering *some* plan of indicating the position of the guns' sights almost absolutely indispensable. That above described, the writer was informed by an officer of the Colossus, has proved perfectly successful in actual practice.

On some of the larger European ships-of-war, and on a few United States vessels, arrangements have been made for firing the guns by electricity. This is usually accomplished by causing the current from an ordinary zinc-carbon battery to pass through what is known as an electric primer, inserted in the vent of the gun. The primer, as used in the United States service, is simply a quill tube nearly filled with small-grained powder, and containing a fine platinum wire wrapped with a wisp of gun-cotton. The platinum wire is connected with the wires of the electric battery. When the battery circuit is closed, the platinum becomes instantly white-hot, thus igniting the primer and firing the gun. The firing-key, with which the circuit may be closed at pleasure, is placed in the pilot-tower, or in some other position where it is directly under the control of the commanding officer, and the circuit is of course kept open until the instant of firing. The advantages claimed for such a system are many. Obviously, under some circumstances, as, for example, where it is desirable to concentrate the whole broadside upon a certain point, and to fire all the guns together, such an arrangement would have a great advantage over the ordinary method of depending upon the simultaneous action of the gunners. Again, it is no uncommon occurrence in battle for a ship's gun-decks to become so enveloped in smoke that the enemy cannot be seen by the men at the guns, and in such cases, with an electric system, the firing could be done by an officer clear of such an obstruction. Usually the electrical appliances admit, also, of the guns being fired singly and in succession; and for cases where the ship is rolling heavily from side to side, an "automatic circuit-closer" is sometimes employed, which, *after the regular firing-key has been pressed*, closes the circuit and discharges the guns the instant the vessel reaches an upright position.

Electric "logs," for measuring the speed of a ship, usually depend for their action upon the revolutions of a small screw-propeller, or "fan," attached to the end of a short electric cable, and trailed through the water astern of the vessel. The velocity with which the fan revolves at any given speed through the water has been previously determined by an actual trial. The wires of its cable are connected with a battery on board the ship, and its revolutions periodically open and close the circuit of the battery, which action is communicated by suitable mechanism to a register, or dial, so graduated as to show the corresponding speed in miles and tenths. While such an apparatus is valuable for the purposes of navigation—since it affords an accurate measure of the distance passed over by the ship in the *interval* between any two readings of the dial—it fails to show the speed of the vessel at the *moment of observation*.

This latter knowledge will be an important factor in future naval fights. The commander of a modern ship of war, engaged in battle, must be able to ascertain the rate at which his vessel is moving at any desired moment, in order to make allowance for the deflection of shot, and still more for that of torpedoes, due to the speed of the ship at the instant of their discharge. Hitherto, so far as the writer knows, only a single



Ship-of-War using her Search-lights.

"log" has been designed which accurately furnishes this essential information. This instrument is an ingenious "speed indicator," the invention of Lieutenant Hogg, of the United States Navy, but of which, since it depends upon no principle of electricity (but upon that of the vacuum-gauge), no more than the mere mention of its existence can be here made.

The question of introducing electric motors in ships-of-war, to take the place of the numerous small steam-engines now required on board for various purposes, is one that is occupying the serious attention of naval authorities. That such a substitution will be made in the near future seems now assured. An electric current is the most convenient method of transmitting power from one point to another, at a considerable distance, that has been yet discovered. It is also the most economical where the conditions, as on board a modern man-of-war, require the power to be conveyed from a single source to a number of different points of application. Yet, at the present writing, no use of an electric motor is made in any of the great navies of the world. It has been left to the United States to take the initial steps toward its introduction, by employing electricity to work one of the eight-inch guns of the steel cruiser Chicago. This motor is to be supplied with the requisite electric current by connecting its wires with those from the dynamo used for lighting the ship. Should this experiment prove successful, as it undoubtedly will, similar motors will probably be applied to the remaining eight-inch guns of the Chicago; and the system, or some modification of it, will doubtless be extended to other ships now under construction for the United States Navy.

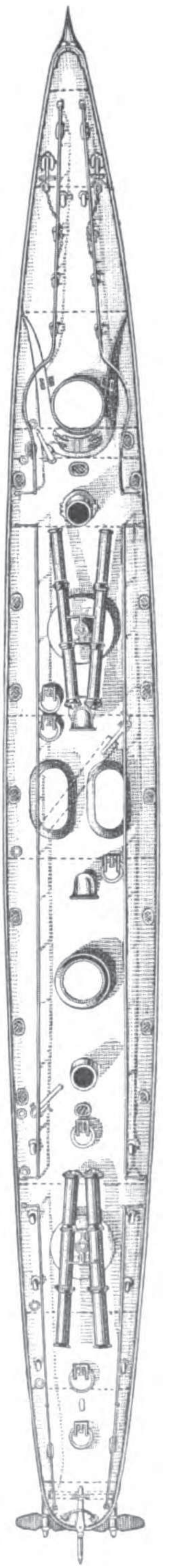
Electricity has been the chief element in the development of those remarkable inventions known as auto-mobile, or "fish," torpedoes. They are, with few exceptions, steered, propelled, or exploded by an electric current; and in some all three of these applications are made. In a former number of this Magazine * the present writer has described the mechanical features of the most ap-

* "Modern Aggressive Torpedoes," SCRIBNER'S MAGAZINE, April, 1887.

proved torpedoes of the present day. No ship-of-war is now regarded as efficient whose armament does not include a number of these weapons. It will be sufficient here to recall to the memory of the reader that the "Whitehead" is the torpedo in general use in the navies of Europe. Briefly, it is cigar-shaped, from 9 to 19 feet long by 11 to 16 inches diameter, made of thin steel, propelled by compressed air, and carries an explosive charge of gun-cotton ranging from 40 to 105 pounds. In practical use the torpedo is discharged at the enemy's vessel through a tube, which may be mounted on board ship either above or below the surface, and upon reaching the water it is propelled by its own engines. The initial motion, or "discharge," is effected by an electric fuse which ignites a very small charge of gunpowder placed in the tube behind the torpedo. The wires from the fuse are connected in the circuit of a battery, and lead to the pilot-tower, where the firing is accomplished by the usual means of a key-board under the control of an officer. The illustrations on this page, and opposite, show the tubes in place on the deck of a torpedo-boat, and also represent them separately on a larger scale. It will be observed that they are mounted on a turn-table, so that they may be pointed in any direction, and that they are set at a slightly divergent angle with each other. By this arrangement of tubes—that now most approved by the naval authorities of Europe—two torpedoes are discharged at the same instant, and it is believed that the slight divergence of their courses will greatly increase the chances of either one or the other striking the enemy's ship.

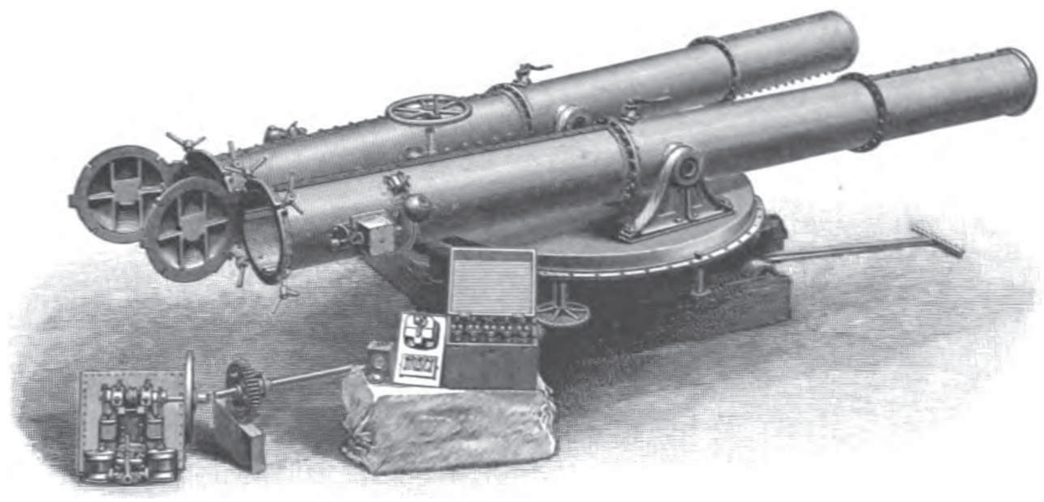
An ingenious application of electricity is employed to explode the projectiles discharged by the pneumatic guns with which that remarkable craft the United States dynamite-cruiser Vesuvius is to be armed. These projectiles are, in fact, aërial torpedoes, and for the 15-inch guns now proposed for the Vesuvius, they will carry a charge of six hundred pounds of explosive gelatine. High explosives, such as dynamite, gun-cotton, and explosive gelatine, require to be detonated in order to develop their full energy; and for this purpose fulminate of mercury has been found to be best adapted. It has been found, also, that a very much greater destructive effect upon a target is obtained when the explosive charge of an elongated projectile, like those to be used in the guns of the Vesuvius, is first ignited *at the rear end*, or "base," instead of at the point—and recourse was had to electricity to accomplish this result. The fuse consists of a fine platinum wire—wrapped with a fibre of gun-cotton and embedded in fulminate of mercury—connected with the circuits of two small galvanic batteries carried within the projectile itself. With either of these batteries active, the platinum wire becomes instantly heated to redness and explodes the charge. In one, the electrical connection is kept broken until the projectile strikes some solid body, such as a ship or a target, when the shock of impact closes the circuit and causes the explosion. The circuit of the other battery is complete; but the battery itself requires to be moistened in order to become active, and the explosion consequently takes place after the projectile has sunk below the surface of the water.

The use of elec-



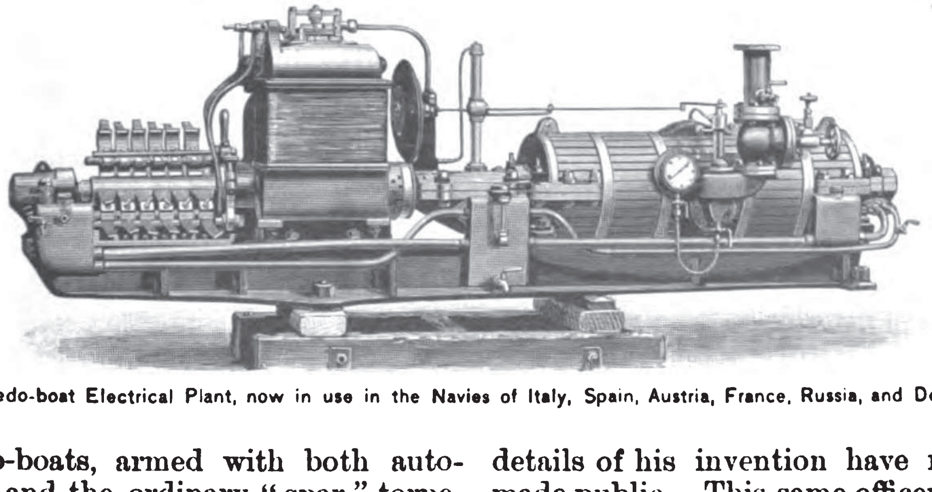
Deck-plan of Yarrow Torpedo-boat, showing discharging tubes mounted on turn-tables.

tricity for the propulsion of boats has met with considerable success. But the low speed hitherto attained by such



Revolving Deck Tubes for Yarrow Torpedo-boats, showing electrical discharging apparatus.

vessels, and the fact that their motive power is necessarily derived from storage-batteries, which are notoriously uneconomical, have prevented their use as torpedo-boats. Yet, next to great speed, the most essential quality of a torpedo-boat is noiselessness, and this requisite electric boats possess in an unsurpassed degree. This latter may even become, under some circumstances, of more importance than high speed ; for on a dark night, or in a fog, the success of a torpedo-boat will often depend upon a silent, unperceived approach, and the suddenness of its attack. Hence, it appears safe to predict that electric



Torpedo-boat Electrical Plant, now in use in the Navies of Italy, Spain, Austria, France, Russia, and Denmark.

torpedo-boats, armed with both automobile and the ordinary "spar" torpedoes, will find a place in the navies of the future.

For *submarine boats* no motive power yet discovered seems comparable with electricity. High speed in vessels of this class will probably never be of the first importance, since they are mainly designed for attacking ships at anchor. The part such vessels are destined to play in naval warfare is an interesting and unsettled question, and their development is being closely watched by the naval powers of the world. Hitherto, when subjected to rigid practical tests, they may be said to have been unsuccessful.

Lieutenant Fiske, of the United States Navy, has designed very recently an electrical "range-finder," for measuring the distance of an enemy's ship or of a target, but at the present writing the details of his invention have not been made public. This same officer was engaged for some time on board the steel cruiser Atlanta, in conducting a series of experiments with the object of devising some means of telephoning or telegraphing, either through the air or the water, in order that ships might be enabled to communicate with each other in a fog, where signals could not be seen, or at night, when, as in the proximity of an enemy, the use of signal-lights might not be advisable. But while "results were obtained which were in themselves encouraging, they seemed to indicate the impracticability of the scheme."*

In the French Mediterranean fleet, during recent naval manœuvres, a novel use of the telephone was made in connection with a balloon. The latter, carrying with it a telephone connected with the ship, was secured to the deck by a rope which allowed it to rise to the height of about a thousand feet. From this lofty point of observation an officer watched through a telescope the operations of a distant squadron representing the enemy, and from time to time telephoned the results of his examination to those on the vessel below.

A number of other applications of electricity, such as electrical steering-gear, electrical engine-room annunciators, etc., have been made on ships-of-war; but they have either proved to be unsuccessful, or, if successful, they were found to be of such doubtful utility as to render their adoption unadvisable.

The development of electricity is so rapidly progressing that no limit to its future naval applications can now be assigned. But, with the assistance of the Office of Naval Intelligence, it may be safely assumed that the proposed "New Navy" of the United States will have the benefit of every useful naval invention. This office, to which the writer is greatly indebted for information and illustrations included in this paper, is a branch of the Navy Department specially charged with the duty of keeping informed upon the latest advances in all branches of naval science throughout the world.

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## II.—IN LAND WARFARE.

*By John Millis, First Lieutenant, Corps of Engineers, U. S. Army.*

It is not an uncommon observation that all the great inventions and discoveries which have contributed to mark the present century as the most extraordinary in the history of the world's progress have been immediately employed, so far as possible, to the "abominable end of annihilating mankind;" but though it is true that a majority, perhaps, of the improved appliances of modern warfare have thus resulted, from the application to military purposes of discoveries which first found practical use in the industrial or commercial world, the high degree of perfection which has been attained in the development of military methods and material of the present time is also largely due to the special devotion to this particular object of the best educated intelligence and inventive talent.

To the reader accustomed only to the peaceful occupations of business or professional life this may seem like a perverted application of human knowledge and technical science, and one entirely inconsistent with modern ideas concerning the proper relations which should exist among civilized nations. It is evident, however, on reflection, that there can be no possible insurance for the nation against attack and defeat by a foreign power, except the most perfect preparation to meet and resist such an attack that the skill and knowledge of man can devise. Moreover, from a humane point of view, it is a gratifying reflection, and a fact fully established by history, that with the improvements and advancements in military science and art of modern times, warfare now consists of much shorter conflicts in arms than was formerly the case, and though the action is thereby rendered vastly more intense while it continues, it also becomes the more decisive, hostilities are terminated the sooner, and the loss

* Report of the Office of Naval Intelligence.

of life is actually less; so that instead of contributing to the "abominable end" of exterminating the human race, the application of the most advanced discoveries and inventions to the art of war has in reality mitigated the distressing results of armed conflict.

The numerous and constantly increasing adaptations to the needs of man of that wonderful and still mysterious force or agent called electricity have naturally attracted great attention in the military world, both from the inventor who is inspired by the hope of a large pecuniary reward, and also on the part of those who have adopted "the service" as a life work.

Since a greater portion of the details of the so-called "operations of war" are in reality only the operations of peace greatly intensified and prosecuted under more difficult and exacting conditions, it will be seen that nearly all the industrial uses of electricity find a more or less direct application for military purposes; but it is proposed to present here only a brief review of some of the more important of these applications, together with references to certain uses of electricity which are peculiar to the military art.

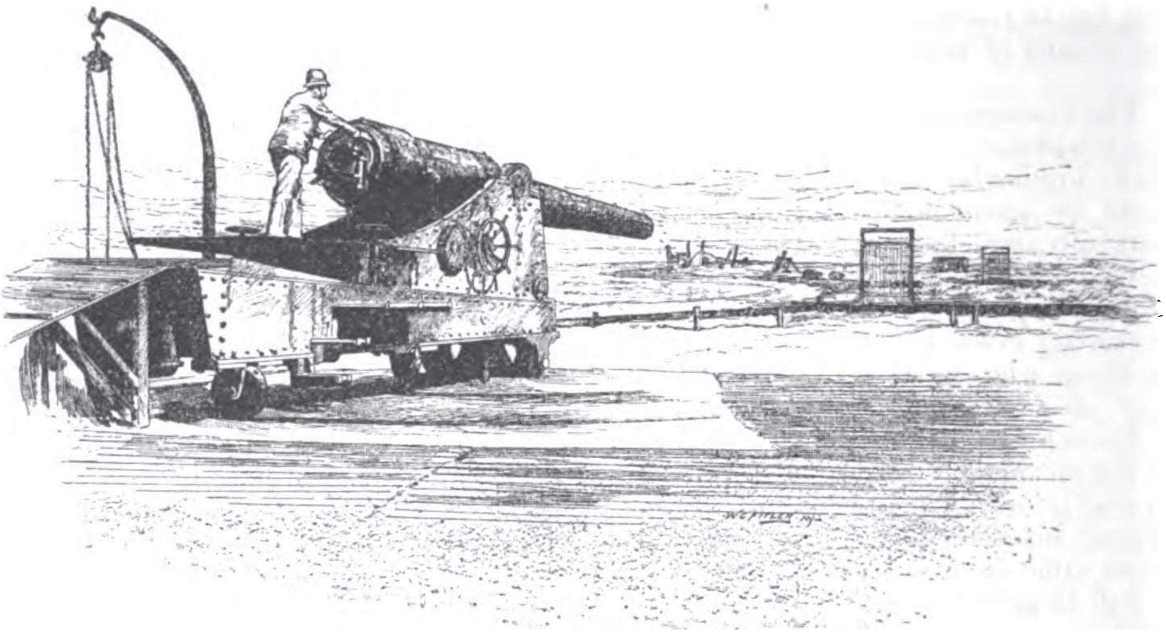
It must be borne in mind that the preparations for war which are made in time of peace are often of necessity more or less tentative and experimental in their nature, requiring the test of actual service in time of war, or, at least, in the field, to determine their practical utility, to develop their defects, and to suggest the remedies. It would therefore be futile to attempt a reference to many ingenious and promising devices for use in war which have been suggested and made possible by the more recent advances in electrical science, but for the actual trial of which there has, fortunately, been as yet no opportunity.

Beginning with the permanent military establishment in time of peace, we find that electricity renders important assistance in maintaining this establishment in a proper state of drill, discipline, and general efficiency, as well as in the manifold technical processes connected with the fabrication of arms, ammunition, equipments, and other war material.

The soldier must first be supplied with an efficient weapon, and in the design, manufacture, and test of improved fire-arms many intricate problems arise, the solution of which could not be satisfactorily effected without the aid of electricity. One of the most interesting of these problems relates to ballistics, or the scientific study of the motion of a projectile when fired from a gun. It is evident that in order to predict the range of the shot, and its penetration or effect on striking the object fired at, and to determine the accuracy and efficiency of the gun, of the powder, and, to a certain extent, of the projectile itself, an accurate knowledge of the velocity imparted to the shot when the weapon is discharged is of the greatest importance to the ordnance officer. The rate at which the projectile moves when leaving the muzzle of the gun is called its *initial velocity*, and since its rate of motion rapidly diminishes during flight, the observations to determine this initial velocity must be confined to a short portion of the projectile's path immediately after it is clear of the gun.

With modern high-power guns the shot is often given an initial velocity of more than two thousand feet per second, which is at the rate of a mile in less than three seconds, and hence it will be understood that the determination of the initial velocity involves, besides ascertaining the exact instant at which the shot passes two fixed points near the beginning of its path, the precise measurement of an extremely small interval of time.

Suppose a wire to be stretched across in front of the muzzle of the gun, and at a short distance from it, this wire forming part of a complete electric circuit, which includes also an electric battery and an electro-magnet. When the gun is fired this wire will be broken, the circuit interrupted, and the armature of the magnet released at the instant that the projectile reached the wire in its flight. Now imagine a second wire stretched across the path of the shot, at a point one hundred feet in front of the first one, with a similar arrangement of electric circuit, battery, and electro-magnet. The breaking of this second wire by the flying projectile will release the armature of the second magnet, and if the interval of time between the re-



Measuring the Velocity of a Cannon-ball by Electricity.

lease of the two armatures can be determined, the velocity of the projectile is easily calculated. If the projectile has a velocity of 2,000 feet per second, and the wires are 100 feet apart, the interval of time will be one-twentieth of a second, and since it is necessary to know the velocity of the shot to within a few feet per second, an instrument capable of measuring the time-interval to within the five-thousandth part of a second is required ; and the instrument must also record its measurement, since the mind cannot conceive, and much less note, such a very brief period.

These exacting conditions are completely fulfilled by the electric chronograph, which is an instrument embodying the two electro-magnets already referred to, together with a recording apparatus, and certain attachments for making necessary adjustments, etc. The armature of the first magnet is an iron rod about three feet long, which is suspended in a vertical position from the core of the magnet. The breaking of the first wire releases this rod, allowing it to fall, and when the second wire is broken the armature of the second electro-magnet, which is placed a short distance below the first, is also released, operating a sort of knife which strikes the side of the falling rod, and makes a cut or indentation. The distance of this cut from the end of the rod shows exactly how far the rod dropped while the shot was passing over the distance between the first and second wires, and the corresponding interval of time is readily computed from known laws of falling bodies. Knowing this interval and the distance between the two wires, the initial velocity of the projectile is easily determined.

In testing large guns at the United States Proving Ground at Sandy Hook, New York Harbor, two open frames or targets are set up in front of the gun, and the wire to be broken is strung many times back and forth from one side of the frame to the other, to better insure the rupture of the circuit by the shot as it passes through the frame. From these targets conducting wires lead to the laboratory near by, where the chronographs, batteries, switch-board, and other apparatus are located. In order to obtain more reliable results two or more chronographs may be used for testing the same shot, and the laboratory at Sandy Hook is provided with a number of these instruments.

Another interesting application of electricity at the Proving Grounds is the employment of a small incandescent electric lamp, mounted in connection with a magnifying mirror on the end of a long rod, for examining the bore of large guns. By the aid of this apparatus most complete inspection can readily be made of the condition of the chamber and rifling, and any erosion or wear, which frequently occurs from the action of the projectile and the gases from the powder, can at once be detected. Photographs of the interior of the gun are even taken by means of the electric light, and the information obtained by these means is most valuable, and is manifestly more satisfactory than that given by the method of taking impressions of the bore in soft rubber.

Photography has also been made use of in studying the motion of the projectile. In the case of large guns instantaneous views of the shot during its flight have been successfully taken by means of a camera provided with a quick-acting shutter. This method is not applicable, however, to small arms. A rifle-bullet is a very small object, and the camera must be set very near its path in order to obtain a picture of sufficient size to be of use; but the nearer the instrument is placed to the moving object to be photographed, the more rapid is the motion of the image over the plate, and no "instantaneous" or quick-acting shutter could possibly be made to operate with sufficient rapidity, or at the proper instant, to give a sharply defined picture. The desired end is accomplished, however, by the aid of electricity. The camera is provided with an extremely sensitive plate and placed in a dark room, through which the bullet is made to pass. The instant the bullet is in front of the camera it breaks an electric circuit, producing a spark which illuminates the bullet for an instant, and its image is impressed upon the sensitive plate. The duration of the electric spark is almost infinitesimal, and since the plate is affected only during the continuance of the spark, a well-defined photograph of an object moving at a greater velocity than that of sound is obtained. Such pictures show the condensation of the air in front of the bullet, the vacuum left behind it, and the eddies and currents produced in the surrounding atmosphere by its motion; and they afford information which is of value in determining the best shape to be given to the projectile in order to reduce to a minimum the resistance which the air opposes to its flight, and so increase its range and effect.

The gun and ammunition having been brought to a proper degree of perfection for efficient service, electricity again comes to the soldier's aid in assisting to teach him how to use his weapon.

The electrical target, invented by an officer of our service, is designed to remove the dangers of small-arms practice and to facilitate instruction in marksmanship. This target is made of metal, its surface consisting of a great many separate plates accurately fitted together, and each one having a circuit-closer at the back, and admitting of a slight movement independent of the others. Each circuit-closer is connected by a wire with an annunciator located at the firing stand. When a shot strikes any part of the target the corresponding plate is slightly depressed, its circuit-closer operates, and the position of the shot on the target is at once indicated by the annunciator. The necessity of having a man at the target to mark the shots is thus obviated, and mistakes in marking, as well as accidents, which frequently happen from firing when the marker is exposed, are prevented.

As the telegraph was the pioneer among the great industrial applications of electricity, so it was also one of the first electrical inventions to be systematically and generally adopted as a necessary adjunct to the methods of warfare, and its recognized importance will be understood from the fact that the military organizations of nearly all civilized nations now comprise a special telegraph or signal corps, which is instructed and trained in all the duties and operations pertaining to the electric telegraph. Indeed, it has recently been remarked by a foreign military authority, that "so important will be the part played by military telegraphy . . . that the army which has the most efficient system of electric signalling will hold a trump card which may be a decisive influence on the game in any future European war."

Telegraph lines, constructed primarily

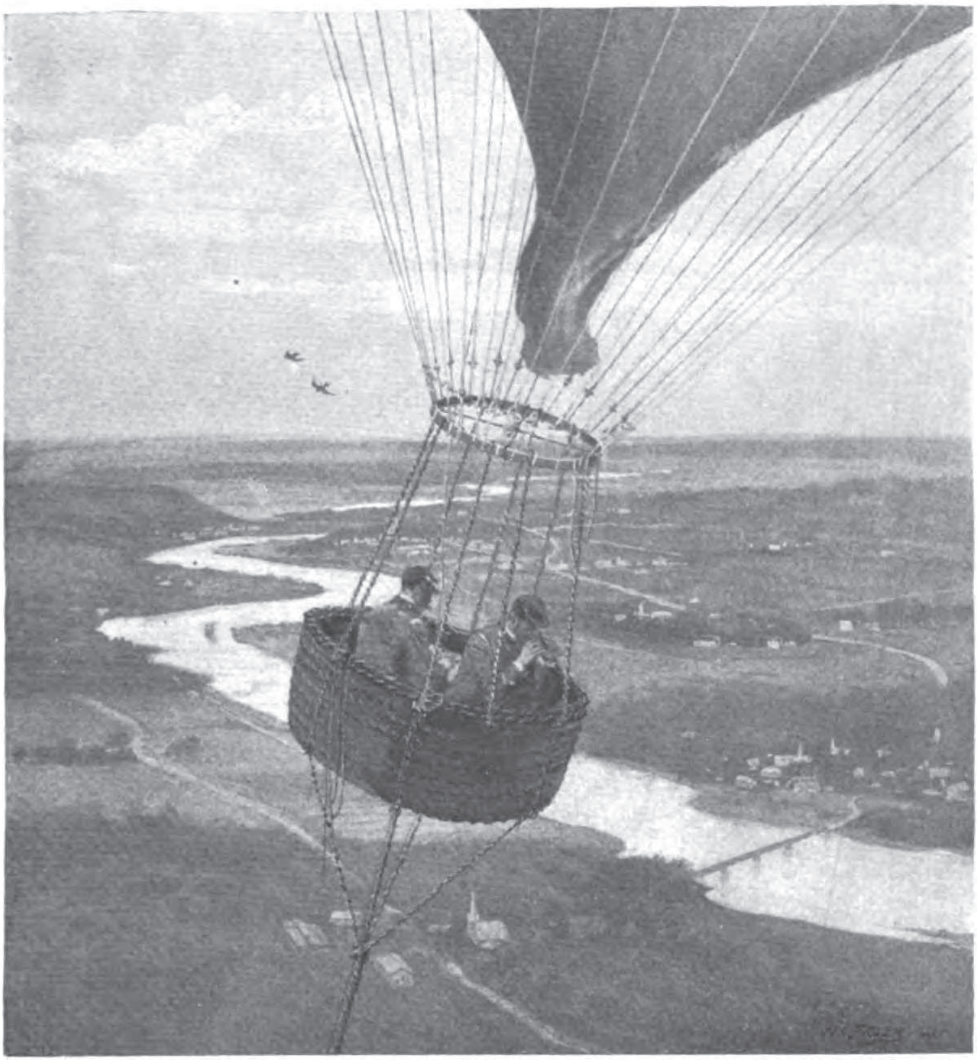
for commercial purposes only, render valuable service in the various duties connected with the regular maintenance of the permanent military force, and upon the approach of hostilities such lines may prove indispensable. The army must then be promptly mobilized, or placed in a condition for active service, and means of rapid communication between the capital or general head-quarters and the centres of the various separate organizations is essential; as is also the prompt transmission of the news of the approach of the enemy, of his arrival on the sea-coast or frontier, and of his movements generally.

The army having been mobilized and placed in the field, the commanding general must maintain communication with the home government and with his subordinate commanders, who may be at a distance. In all these cases commercial telegraph lines are utilized to the fullest extent possible, as well as under any other circumstances where such lines exist and can be made available.

Permanent telegraph lines are frequently erected, especially for military purposes, to connect established posts, depots, or stations with each other and with head-quarters, or to insure communication between other places which in time of war are likely to become of strategic importance. Such military telegraph lines being constructed in time of peace are, of course, similar in all respects to commercial lines.

But in active operations in the field, in presence of the enemy, and perhaps in the enemy's country, entirely new conditions are met with. The commanding general may find himself in a region where none of the conveniences of civilization ever existed, or where all such conveniences that may have existed have been destroyed. His command may extend over a large area, and some of the corps or divisions may be miles away, with dense forests, marshes, streams, mountains, or country occupied by the enemy intervening. Communication must be established through the nearest point to which the permanent lines are still in operation with the home capital, and it is absolutely essential that the commander be provided with the means of transmitting his orders to his subordinates, and of receiving intelligence of their positions and movements, and of those of the enemy, if he is to have

Running the Wires of a Field-telegraph.



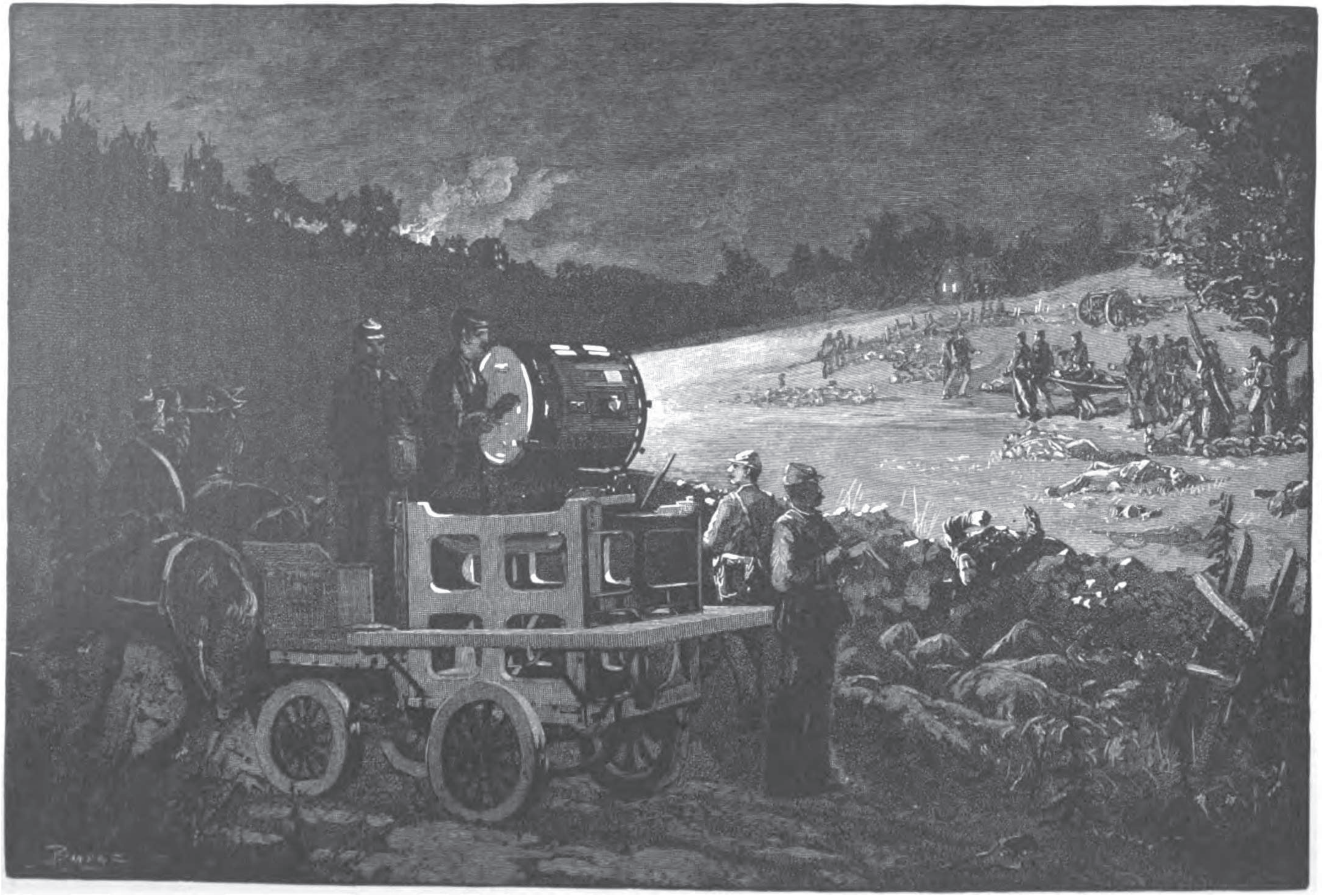
Telegraphing Military Observations from a Captive Balloon; the wire along the cable.

any hope of successfully executing the plan of operations which it is his duty to carry out.

The Field Telegraph Corps now comes to his aid. This corps is provided with its train of wagons or carts, drawn by horses or mules, and carrying wire, poles, instruments, etc., and the tools and material needed in erecting the lines, in taking them down, and in making necessary repairs. For lines which are to be in a measure permanent, like those erected to maintain communication between the field of operations and the home government or the general headquarters, the wires will be put up in the ordinary manner, making use of such available material for poles, etc., as may be found in the vicinity.

In the case of temporary lines, which must be more hastily constructed and removed, the wagon carrying the wire is driven over the route and the wire reeled out along the ground, to be afterward raised and supported on insulators attached to trees, buildings, fences, etc.; or where such supports are not available, to light wooden poles carried for the purpose. The batteries, instruments, etc., can be set up in the wagon, which is thus made to serve as an operating station.

For still more rapid work, wire or cable having an insulating covering throughout is used, and this is reeled out along the ground, crossing marshes, streams, etc., if necessary, when it is ready for immediate use without requiring insulating supports. In crossing roads, and at other points where the wire would otherwise be exposed to injury, it is raised on poles or may be buried in the ground. In rough, mountainous, or thickly wooded regions, where



Using the Search-light on a Battle-field—Bringing in the Wounded.

wheeled vehicles cannot be used, the wire and other material is transported on pack animals, and in running short lines which must be very hastily established in difficult situations, the reels may even be carried by men on foot.

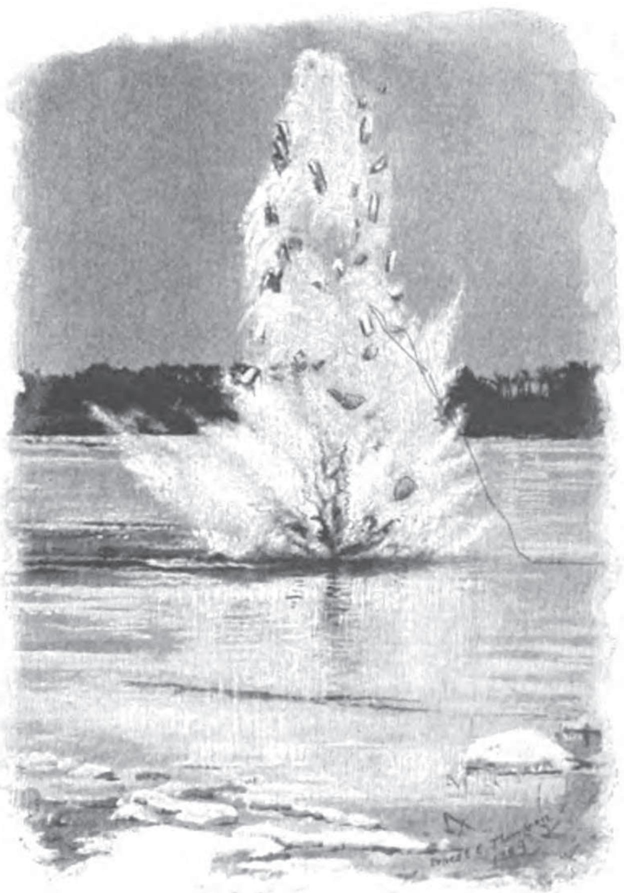
For operating the line an instrument similar to the ordinary Morse apparatus, arranged in compact form, is generally used; but the telephone has also a limited application for the purpose, and an improved instrument has recently been devised for the field telegraph service which will work for moderate distances through an ordinary bare wire laid along the ground or through the wire of fences.

In the use of captive balloons for observing the strength and position of the enemy or of his works, or for obtaining information regarding his movements, the telegraph or telephone furnishes the best means of communication between the observers in the car of the balloon and persons on the ground. The instrument in the balloon is readily connected with that below by wires carried along or enclosed within the cable by which the balloon is secured, and the results of the observations, instructions or orders, etc., can be communicated almost as easily as between two stations on the ground.

The members of the Telegraph Corps must of course be thoroughly drilled in all the manœuvres connected with packing, transporting, erecting, operating, and taking down the special apparatus of the field signal train, and they must be able to operate the apparatus in commercial use as well. Besides having a thorough knowledge of the ordinary or Morse code, they must be familiar with various secret codes and ciphers, adapted for use in presence of the enemy, and they must be instructed in the methods of destroying or interrupting the telegraph lines of the enemy and intercepting his messages.

Recent improvements in synchronous telegraph apparatus, the action of which depends upon the continuous motion in perfect unison of two instruments in electrical connection, but at different stations, have rendered it practicable to make, at a distant station, an exact reproduction of any writing or drawing executed on suitably prepared paper and placed in the instrument at the sending station.* Though the principle of this instrument is not new, and it has never been used to any extent for commercial purposes, the improvements referred to give promise of rendering the system of great value in sending vastly more complete and reliable information concerning the plans of forts and other works of defence, the disposition of troops, maps of the country, etc., than could possibly be conveyed in words, and with a great saving in time and almost absolute security against the interception of the message by the enemy.

But even the field telegraph may fail, as when it becomes necessary to transmit messages over large bodies of water, or across intervening country which on account of its occupation by the enemy or from some other cause is inacces-



Torpedo Explosion under Ice.

* See SCRIBNER'S MAGAZINE for July, 1889, page 15.

A Mine Explosion during an Advance.

sible. Flashes of light, produced by the field search-light apparatus, directed upon the clouds or upon high terrestrial objects in the vicinity, may then be employed, or signals may be sent by means of incandescent lamps sent up in a balloon and made to flash by manipulating a key introduced into the circuits. This is a method of signalling which cannot be interrupted by the enemy, though it is, of course, only available at night and in clear weather.

The search-light apparatus consists of the well-known arrangement of a powerful electric lamp placed in the focus of a reflector, so contrived that the lamp and reflector can be easily turned and the beam of light sent in any desired direction. For field service the lamp and the steam-boiler, engine, and dynamo for operating it, are mounted on wheels for facility in transportation. The more important uses of this light are to disclose the position and movements of the enemy; to blind and confuse him in the event of an attack at night; to enable the fire of a fort to be properly directed; to facilitate night movements of the army, and the construction of earthworks or other hasty defences. After an action the light may also be employed to search out and care for the wounded on the field of battle, and it assists in the merciful work of the surgeons by enabling them to promptly perform delicate operations which otherwise could only be done in daytime (p. 430).

It is, however, in immediate connection with the high explosives that the military adaptations of electricity have received their most perfect development and have contributed to the most astonishing results, and there is probably no military weapon with which the general public has been made more familiar by repeated descriptions and illustrations than that class of instruments of destruction known under the general name of torpedoes.

The almost universal adaptability of

the method of firing charges of gunpowder, dynamite, gun-cotton, or other explosives, by means of the electric spark or an electric fuse, follows from the great ease and facility with which the firing circuit can be established in almost any situation, however difficult or unfavorable, and carried to almost any point, however remote; thus enabling the operator, by simply manipulating a key or electric exploder, to fire the charge from a place of perfect security, with certainty and at the proper instant. There is no "slow match" or powder-train liable to be ruptured, to become damp, or to be found inoperative from other causes when most needful; and the unsatisfactory percussion cap and lock, always subject to accidental discharge, are also done away with.

More especially in permanent fortifications, and in the complete and complicated systems of defence established to protect important seaports, does the electric apparatus, or "plant," become an important factor in the organization, and under these circumstances it requires a special corps of skilled operatives carefully trained in its establishment, care, and manipulation.

The main station, containing the steam-power, dynamos, batteries, etc., is located in a thoroughly secure place within the work, or it may even be removed to a point some distance away and the conductors carried to the fort under ground. Electric motors will enable the aiming and manipulation of the heaviest guns, mounted on "disappearing gun-carriages," to be effected with the greatest facility, and they will also be brought into use in moving and hoisting the enormous charges of explosive and projectiles which constitute the ammunition of modern high-power ordnance.

The guns have electric fuses, or primers, connected with wires which are led to a secure place of observation, where the commanding officer, provided with instruments which enable him to accurately determine the position and distance of the enemy's vessels, has the entire battery of the fort under immediate control, and he can direct and regulate the fire of the guns to the best possible advantage.



The approaches to the fort by land will be defended by ground torpedoes or mines, properly distributed and carefully concealed, and passages over frozen streams or other small bodies of water in the vicinity may be defended in a similar manner. Mines placed under ground or under the ice are also employed in field operations, and frozen bodies of water are readily made passable for friendly boats by blasting with charges of explosive placed on the ice or beneath the surface.

These mines or torpedoes constitute a formidable and much-dreaded means of defence, since they are entirely concealed from sight and their position cannot easily be discovered by the enemy. By providing them with electrical fuses, placed in circuits under control from the fort, they will be absolutely inoperative and harmless until, upon the approach of the enemy, the time arrives for their deadly work. The mines can also be arranged to operate automatically if liable to be disturbed during darkness, or if planted where their location cannot be observed from the fort.

The electric light is also a valuable aid in the general system of defence. The incandescent lamp is particularly adapted to illuminating dark passages and the magazines in which the ammunition is stored, and where, on account of the danger of fire, any other form of artificial light has to be employed with the utmost caution.

In the pneumatic dynamite gun, which has recently received so much attention both from military men and from the world at large, and which undoubtedly will have a place in shore defence, electricity is employed to regulate the explosion of the charge carried by the projectile. The shell carries a small battery in one of its compartments, and this battery is entirely inoperative under ordinary circumstances, rendering the shell entirely safe to handle and place in the gun. When the gun is fired, should the shot fall short, the battery becomes active soon after immersion in the water, and the explosion is caused to take place below the water-line, where it is most likely to do injury to the vessel aimed at.

But it is in the system of defensive torpedoes, or submarine mines, which is provided for obstructing the entrance to the harbor, and which is operated from stations on shore, that we find perhaps a more elaborate and complete arrangement of electric apparatus than in any other portion of the defensive establishment.

The conditions imposed upon this part of the defence are many and exacting, and a vast amount of study and experiment has been devoted to its development and perfection.

A submarine mine consists essentially of a water-tight metallic case containing a large charge of dynamite or other powerful explosive, and provided with an electric fuse and a circuit regulator of peculiar construction. An anchor or sinker is placed on the bottom of the channel it is desired to obstruct, and to this the mine is moored so as to float a short distance below the surface. The fuse and circuit regulator are connected by means of a cable with the testing and firing apparatus in the operating-room, which is located in a secure place within the work on shore, and a large number of such mines are distributed over that portion of the channel through which an enemy's vessel must pass in order to enter the harbor.

Those mines which are placed in the main channel or entrance must be under most perfect control of the operator, since they are planted before the arrival of the enemy, and the channel must afford a safe passage for friendly vessels until hostile ships attempt an entrance. With this object the apparatus can be adjusted so as to merely give warning if the torpedo be struck or disturbed in any way, leaving the matter of firing entirely to the will of the operator or to that of the officer in command of the defence, who is stationed in a suitable place for observation and in telegraphic communication with the torpedo operating-room.

By making suitable connections with the shore firing-circuits, guns ready loaded and aimed over the places where the mines are planted are automatically discharged as soon as a mine is disturbed, thus preventing boat parties from tampering with the system, while the mine itself is reserved for its proper work. Finally, the mine and gun circuits may be so arranged that either the mine alone, or both mine and guns are automatically discharged at the proper instant upon the attempted passage of a man-of-war.

There are, besides, a great many other details connected with this system which cannot be referred to here, but which are, nevertheless, important, since the efficiency of the entire system depends largely upon careful attention to these very details. For example, it is necessary that provision be made for accurate electrical tests and measurements, both while the mines are being planted and after they are established, in order to determine with certainty their condition of efficiency at all times, and to make the best use of such as may give signs of deterioration; and it will be readily understood that with such large charges of deadly explosive and apparatus which is necessarily somewhat delicate and complicated, the greatest care must be exercised in order to prevent serious accidents.

Movable or fish torpedoes also form part of the shore-defence system, and in one of the forms of this torpedo adapted to this purpose the weapon is propelled through the water at great speed by an electric motor connected to the propeller-wheel and driven by an electric current conveyed to it from the dynamo on shore through a cable which the torpedo pays out while in motion. The steering apparatus is also operated electrically from shore through a separate conductor contained in the same cable, and the charge of dynamite which the torpedo carries is exploded either at will or automatically upon striking the enemy's vessel.

Although extraordinary results may reasonably be expected from the employment of the electrical torpedo and dynamite gun for coast defence in future wars that may occur, it must be admitted that there is a popular tendency to overestimate their value and the security which their use will afford the country. Granting that they both are now recognized weapons of warfare, it must be remembered that neither one alone, nor both together, are able to cope


The Sims-Edison Electric Torpedo, steered from the shore.

with an adversary fully equipped with both these and with other modern weapons besides. To provide only torpedoes and dynamite guns for the country's land defence would be as great folly as to send an army into the field with only the modern artillery arm, knowing that it would have to encounter an enemy armed with the same weapon and with the rifle and sabre as well.

# SONG.

*By Duncan Campbell Scott.*

I HAVE done,
Put by the lute;
Songs and singing soon are over,
Soon as airy shades that hover
Up above the purple clover;
I have done, put by the lute—
Once I sang as early thrushes
Sing about the dewy bushes;
Now I'm mute;
I am like a weary linnet,
For my throat has no song in it,
I have had my singing minute;
I have done—
Put by the lute.